Preliminary report on Cyanogen chloride (CNCl) as a possible axis war gas.

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PRELIMINARY REPORT ON CYANOGEN CHLORIDE (CNCl) AS A POSSIBLE AXIS WAR GAS

In answer to a request of May 8, 1943, of the Intelligence Branch of the Chemical Warfare Service as to the possibility that the Axis is manufacturing and intending to use Cyanogen Chloride as a war gas, the following is a summary of information available to us in Washington. It is based on foreign literature, intelligence, and also information given by Dr. F. P. Kerschbaum, BEW consultant, who was assistant to Dr. Fritz Haber in German Chemical Warfare Service in the last war. An inquiry has also been forwarded to London for information on production, capacity, and intentions, and the reply will be forwarded in a supplementary statement as soon as it is received.

Preliminary Conclusion

Our preliminary conclusion is that the past experience of the Germans with this gas, both in peace and wartime, speaks strongly against their planning to use it at the present time as a war gas.

German World War I and Post-War Experience with Cyanogen Chloride

According to H. Hanslian, "Der chemische Krieg," cyanogen chloride is a colorless liquid with a specific

gravity of 1.2 and a vapor density of 2.14, boiling at 15.8 degrees centigrade and freezing at -6.5 degrees centigrade. An intolerable concentration according to German calculations, is 50 milligrams per cubic meter. It has a toxic action similar to hydrocyanic acid, although it was also considered as an irritant and lacrimator.

Cyanogen chloride, made by reacting either sodium or potassium cyanide with chlorine, was used in small amounts by the Austrians and French in the last war as a lacrimator and general toxic gas with no great success. It was dispersed in artillery shells and hand grenades, usually dissolved in arsenic trichloride to increase its stability and vapor density.

Cyanogen chloride, for physical and chemical reasons, has definite limitations as a chemical warfare substance. Early in World War I cyanogen chloride as well as cyanogen bromide were investigated at the Kaiser-Wilhelm Institute in Berlin-Dahlem. As irritants they were found to be inferior to lacrimators already known, such as bromacetone, xylyl bromide, etc., and as toxic gases they were found to be inferior to phosgene and diphosgene. However, it was discovered that the cyanogen halides, and especially the bromide, would penetrate early French gas masks, which had just been captured. Therefore, the Germans at first considered using cyanogen compounds as irritants together with toxic gases like phosgene. However, later models of French masks effectively protected against

cyanogen chloride as well as the related cyanogen bromide. As a result, the small stocks of these two gases which had been manufactured were turned over entirely to the Austro-Hungarian Army to be used in the Balkan, Eastern, and Italian theatres of operation, where inferior types of gas masks offered less protection against both cyanogen chloride and bromide.

The French continued using cyanogen chloride in the form of hand grenades and shells as "Mauguinite" and "Vitrite," the latter being a mixture of cyanogen chloride and arsenic trichloride. The Germans abandoned the idea of using cyanogen bromide in admixture with phosgene. One disadvantage common to cyanogen chloride, cyanogen bromide, and hydrocyanic acid, which made their use undesirable from the German standpoint in the last war, is their relatively high volatility which makes it difficult to maintain lethal concentrations for a sufficient time under field conditions. A more serious disadvantage is their instability and corrosive action on metals such as steel, especially when slight amounts of moisture are present. Therefore, the Germans never reached the stage of considering large-scale use of cyanogen chloride and abandoned plans for using cyanogen bromide. A contrary report to the League of Nations Disarmament Committee (Rapport de la Commission temporaire mixte pour la reduction des armements, A.16 (1924), part IV, Guerre chimique, pages 24 to 30, Geneva, July 30,

1924) that phosgene, cyanogen chloride, and mustard had been the most successful gases in the war is incorrect for cyanogen chloride, according to R. Hanslian, "Der chemische Krieg," Vol. I, p. 267, who based this opinion on Germany's unsatisfactory experience with cyanogen chloride.

Only a few hundred tons of cyanogen chloride and bromide were produced in Germany during the last war, and a small amount of cyanogen bromide by the British and Italians. German production of the necessary raw material, sodium or potassium cyanide, then as well as now, was chiefly in the hands of a group controlled by the Deutsche Gold und Silberscheideanstalt vorm. Roessler in Frankfurt (which included the Dessau sugar refining production of cyanide). The Scheideanstalt had developed cyanide production in connection with its metal extraction processes. The halogenation of the cyanide was probably carried out at the Bitterfeld, Frankfurt-Hoechst, or Ludwigshafen plants of I. G. Farben.

In the post-war period when peacetime uses were sought for former war gas substances, for instance, in manufacturing insecticides and fumigants, the question of cyanogen halides (chloride and bromide) was considered. These substances were investigated because of their irritant properties, which suggested the possibility that they might be used as a safety warning substance added to hydrocyanic acid fumigants for ships, flour mills, etc. For

the same reasons as in the war, it was found that they could not be used because they could not be stabilized and therefore corroded metals.

Capacity for Producing Raw Materials for Cyanogen Chloride

If the Axis wanted to make cyanogen chloride, its manufacture would present no difficulties. The raw materials, chlorine, and sodium or potassium cyanide, are adequately available, as is also manufacturing capacity. How much of the estimated Axis chlorine production of over 600,000 tons, of which at least half could be made available for chemical warfare, (I.R. 191, February 25, 1943) would be devoted to making cyanogen chloride - if it is actually being made - would depend entirely on what assortment of gases the Axis is manufacturing. However, rather than making cyanogen chloride, it seems much more likely that the Axis would be producing mustard, diphosgene, diphenylcyanarsine, or brombenzyl cyanide.

High grade sodium cyanide is produced chiefly from sodium metal, gaseous ammonia, and charcoal in a conversion process developed by Castner. German production of this type of "Castner cyanide," which would be the chief kind used in the manufacture of cyanogen chloride, was concentrated up to 1939 in one plant, the Gutleutstrasse plant in Frankfurt of the aforementioned Scheideanstalt in Frankfurt. In the meantime this production may have been partly or completely shifted to the company's source of sodium

metal at Knapsack near Cologne, which is by far the most important sodium metal plant in Europe. The sodium metal production capacity at the company's "Ville" plant at Knapsack, the only known German plant producing at the outbreak of the war, is estimated at 12,000 to 18,000 tons per year.

According to a BEW report, European <u>sodium metal</u> production is probably distributed as follows:

(Parenthesis indicates reserve plants probably not operating)

Germany:	Ville near Knapsack, Degussa	12 - 18,000	m.t.peryr.
	Rheinfelden near Basle, Degussa	(5,000)	
	Gersthofen near Augsburg, I.G. Farben	(2,500)	
Italy:	Cesano Maderno, Acna-Montecatini	2,500	
	Vado Ligure, Azogeno	(small)	
France:	Clavaux (Isere) Soc.d'Electrochemie	2,000	
	Pierre Bybesse, Soc.Soudiere Electrolytic	(500)	
	Riouperoux, Pechiney	(small)	(probably producing 500 tons together)
Norway:	Vadheim (Sognefyord)	"	
	Fredricksstad (near Oslo)	"	
Total sodium metal produced Axis Europe:		17 - 23,000	
Total " " capacity " " :		28 - 33,000	

If all sodium metal were used exclusively for cyanide production - which obviously is not the case - 35,000 to 45,000 tons of sodium cyanide could be produced annually in Axis Europe, and even more if all the sodium plants were operating.

A second, more limited, source of sodium cyanide would be the hydrocyanic acid obtained from sugar refinery

residues at Dessau (Germany) and Kolin (Czechoslovakia). Under normal conditions, over half the Dessau hydrocyanic acid production of 900 to 1,000 tons, and all the 400 or so tons of hydrocyanic acid output at Kolin is marketed as sodium cyanide. A third source of hydrocyanic acid which is hardly touched because of the high expense, is the recovery of hydrocyanic acid from coke oven gases.

The French production of "Castner cyanide" is centered in the Villers Saint Sepulcre (Dept. Oise) ammonia plant of the Ste. d'Electrochimie et d'Electrometallurgie et des Acieres Electriques d'Ugine. Some "Castner cyanide" is made in the La Barasse (Bouches du Rhone) plant, and for a time some was made at the St. Fons plant of the same company near Lyon. Sodium metal is probably obtained from the Clavaux plant listed among the aforementioned sodium metal plants. The total French sodium cyanide output may be in the magnitude of 1,000 to 1,500 tons a year. In Italy at Crotone the Ammonia e Derivati company produces cyanide. Capacity is unknown but is probably relatively small. It was originally probably intended mostly for fumigation of citrus trees, for which purpose Italy had formerly imported 300 to 400 tons of cyanides annually. A Polish plant at Jaworzno, which formerly was the sole producer of cyanides in Poland agreed about 1928 with I.G. Farben to discontinue production, and it is not known whether production has been resumed in the meantime. No "Castner cyanide" was produced in Czechoslovakia; the cyanide output

of this country is from the sugar refinery residues at Kolin.

A low grade cyanide containing 46 percent sodium cyanide was produced in Germany in the last war by fusion of calcium cyanamide and common salt in electric furnaces. Production by this method was later abandoned for economic reasons. The material, although not suitable for fumigation, could be used for extraction of metals, and for cyanogen chloride production as well if it became necessary. Such cyanide could be produced in large quantities, limited only by the amount of cyanamide diverted for the purpose.

Potassium cyanide is theoretically useable for making cyanogen chloride, but its output is small and is used in Germany for laboratory and pharmaceutical and not industrial purposes. The industrial product of the Castner process as well as that made from cyanamide is sodium cyanide. In fact, for historical reasons, even when the term "Cyankali" (potassium cyanide) is used, it generally refers to sodium cyanide rather than to potassium cyanide.

Before the outbreak of the war, the average production of the leading cyanide producers, Germany, France, and Czechoslovakia, averaged 12,000 tons a year. Since roughly 70 percent of the output was formerly exported, it may be assumed that since 1939 considerable stocks have been accumulated. BEW estimates these stocks at a minimum of 25,000 metric tons of cyanide. If used exclusively for

the production of cyanogen chloride, the accumulated stocks of sodium cyanide of 25,000 tons would be sufficient to produce 30,000 tons of cyanogen chloride. If all the current production of sodium metal were converted into sodium cyanide - which of course is not the case in actual practice - and this in turn into cyanogen chloride, annual Axis European production of 17,000 to 23,000 tons of sodium metal would yield another 34,000 to 46,000 tons of sodium cyanide, which in turn would yield roughly 40,000 to 60,000 tons cyanogen chloride per year.

It is much more likely, however, that sodium cyanide would be used to produce the lacrimator brombenzyl cyanide (1 ton sodium cyanide to 3.6 tons brombenzyl cyanide), or diphenylcyanarsine (1 ton sodium cyanide to produce 5.5 tons diphenylcyanarsine). If any gases of the type requiring sodium cyanide are being made, it is readily apparent that sodium cyanide supplies will not be a limiting factor. The same is true of chlorine. Capacity for the chlorination process is also available in a number of German chemical plants, especially in the larger dye and organic chemical plants. The following German plants could easily make cyanogen chloride in view of their experience and peacetime production program : Bitterfeld, Hoechst, Ludwigshafen, Leverkusen, or Gersthofen. However, no definite information is available to the effect that any of these plants are now making a cyanogen chloride type of gas, either for use alone or in conjunction with other gases. It seems very unlikely

that the Germans have succeeded in overcoming the chemical and physical difficulties in using cyanogen chloride, as mentioned at the beginning of this memorandum. As a result, it is hardly to be supposed that this gas is being produced in any large amounts in Axis Europe.